Qualcomm Incorporated

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March 8, 2019

***Ex Parte* Filing**

Marlene Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Unlicensed Use of the 6 GHz Band - ET Docket No. 18-295; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz - GN Docket No. 17-183; Use of Spectrum Bands Above 24 GHz For Mobile Radio Services - GN Docket No. 14-177

Dear Ms. Dortch:

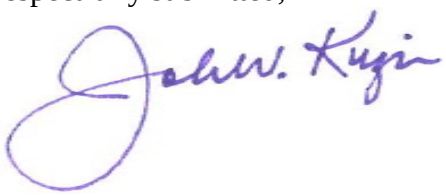
Dean Brenner, Aleksandar Damnjanovic, and the undersigned, from Qualcomm, met with the members of the FCC's Wireless Telecommunications Bureau and Office of Engineering and Technology listed below on March 6 to discuss 5G New Radio ("5G NR") technology in unlicensed and shared spectrum.

Qualcomm discussed the attached deck. We explained how 5G NR deployed in unlicensed and shared spectrum, which is being standardized in 3GPP, can support demanding, compelling Industrial IoT and other applications that require ultra-low latency, ultra-reliable connectivity through using time synchronization and Coordinated Multi-Point ("CoMP") sharing techniques. Today, many factories, hospitals, and other venues rely upon wired technology for these applications and using 5G NR instead will deliver tremendous gains in efficiency, productivity, and other benefits to the public.

Qualcomm also explained the benefits of synchronization of the medium access across the network nodes, as we proposed in our Comments on the 6 GHz NPRM for the U-NII-7 sub-band. Enabling synchronization in a technology-neutral manner in U-NII-7 would allow for improved predictability and support more advanced and flexible spatial sharing techniques in unlicensed and shared spectrum that 5G NR-U and future generations of Wi-Fi technology can utilize for much better performance.

Finally, Qualcomm explained how synchronizing the medium access enables full realization of the performance gains from CoMP. These advanced spectrum access techniques allow for substantially better wireless connectivity than can be achieved today using existing technologies that operate in unlicensed spectrum in an asynchronous manner.

Respectfully submitted,



John W. Kuzin
Vice President and Regulatory Counsel

Att.

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Julius Knapp
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Matthew Pearl
Paul Powell
John Schauble
Becky Schwartz

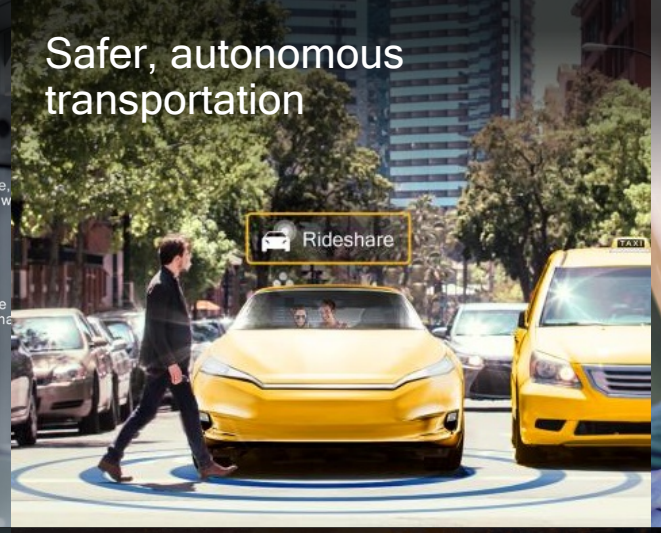
March 6, 2019

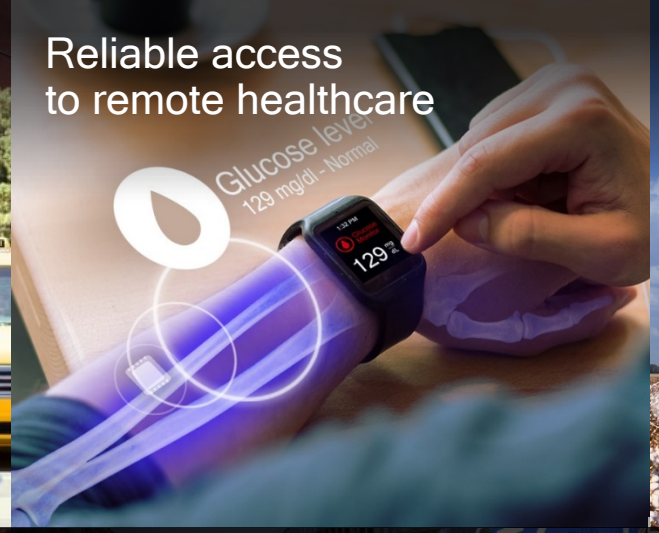
San Diego

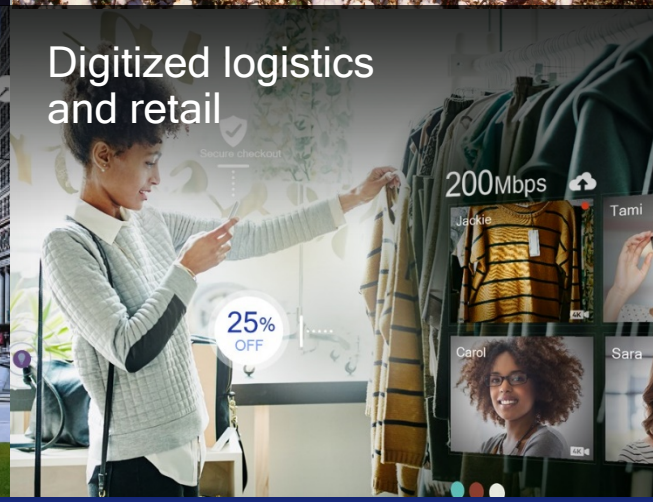
Qualcomm

5G NR in unlicensed and shared spectrum

Qualcomm Incorporated







5G

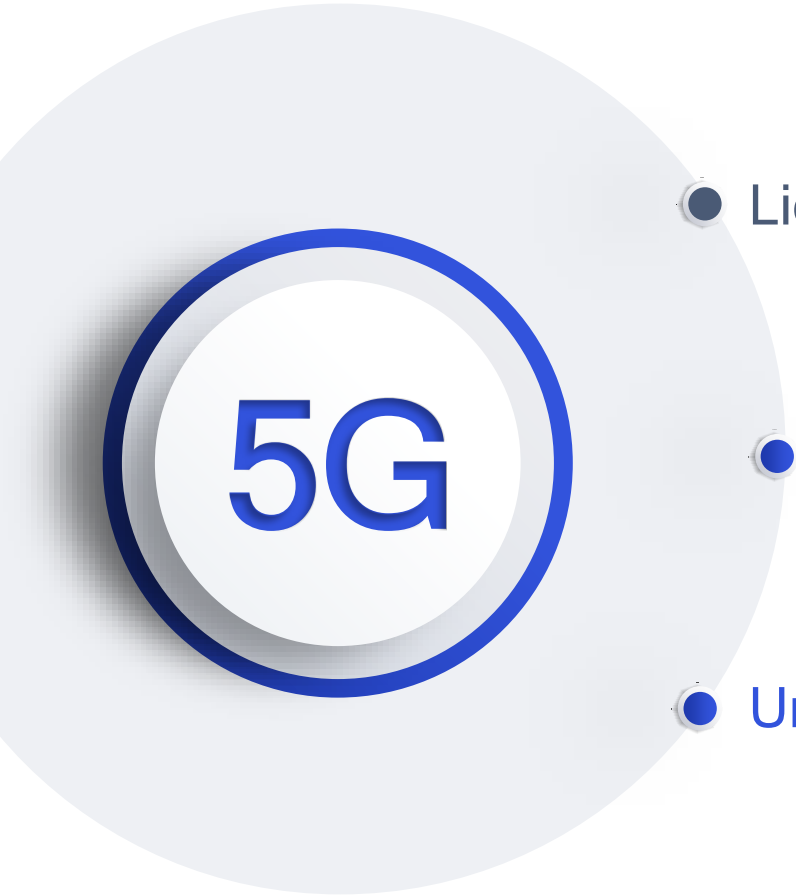
5G will expand the mobile ecosystem to new industries

Powering the digital economy

>$12 Trillion

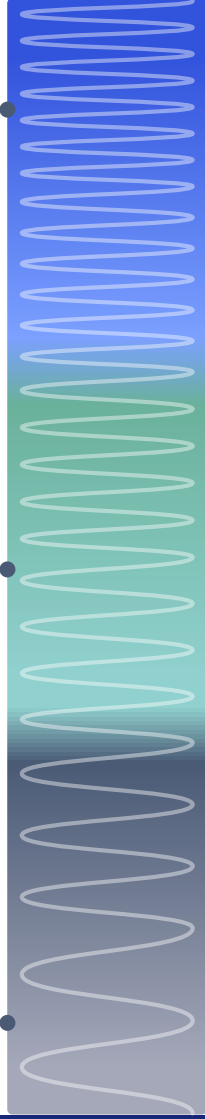
In goods and services by 2035*

* The 5G Economy, an independent study from IHS Markit, Penn Schoen Berland and Berkeley Research Group, commissioned by Qualcomm



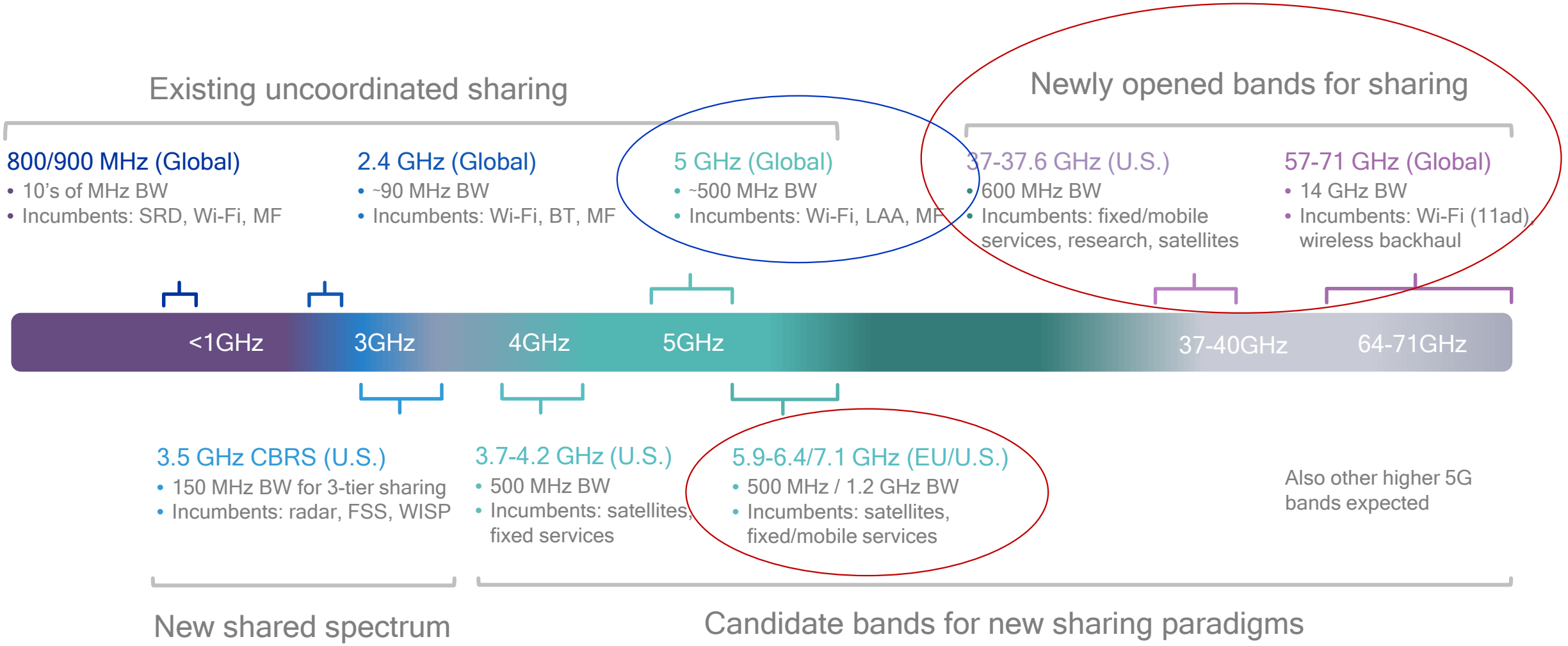
- Licensed spectrum
- Shared spectrum
- Unlicensed spectrum

- Unlocks more spectrum
- New markets/verticals
- New deployment scenarios



New shared and unlicensed spectrum enables new opportunities and expands the ecosystem

Key candidate spectrum bands for 5G spectrum sharing



5G NR-U is valuable for wide range of deployments

5G NR Rel 16 in unlicensed spectrum, fair coexistence with other technologies

Licensed assisted NR-U

Boosting existing deployments

Better user experience with higher speeds

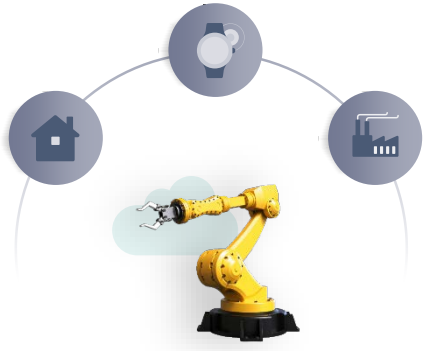
Stand-alone NR-U

Open mobile broadband

Neutral host, neighborhood network

Private networks[1]

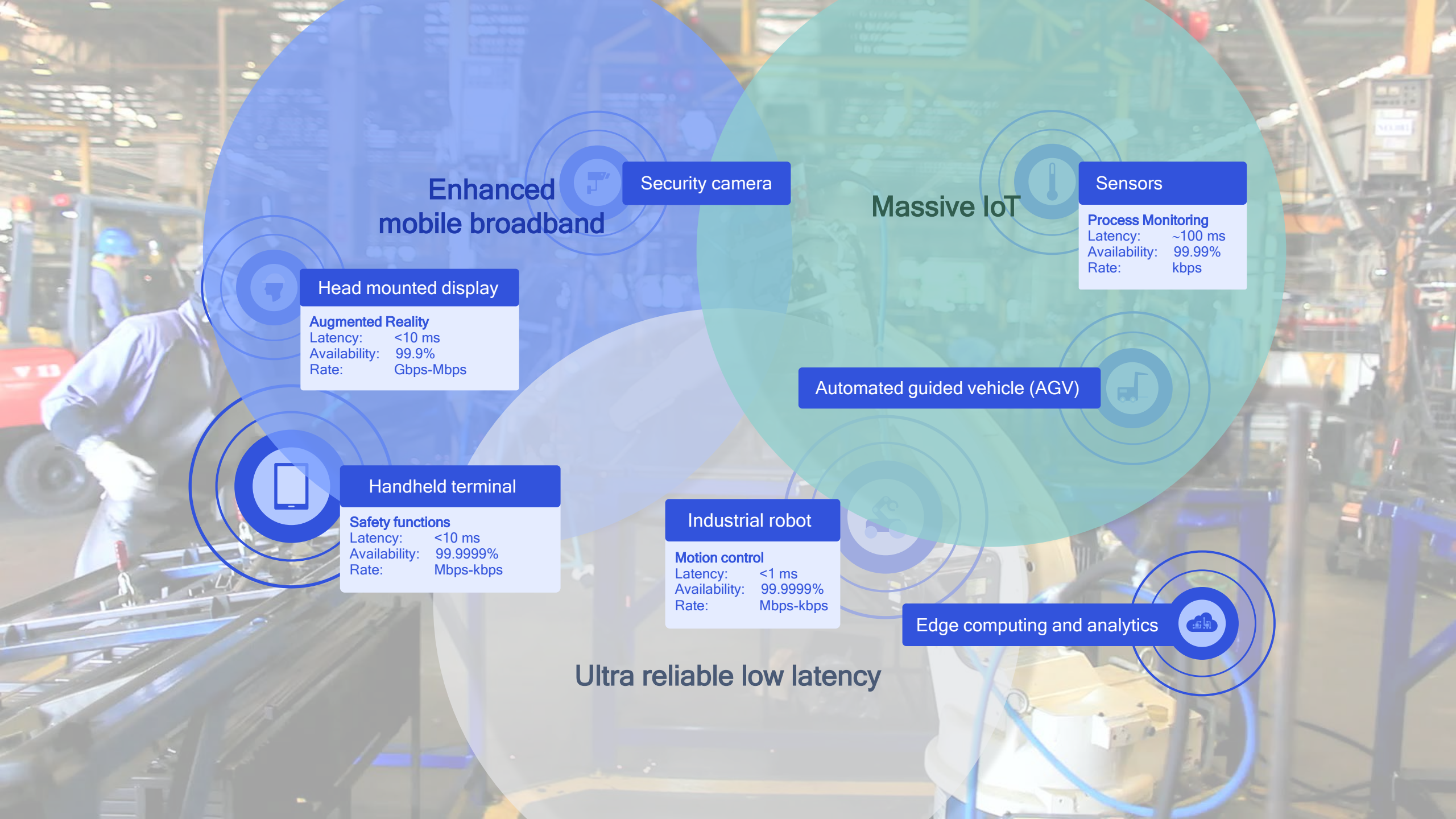
Industrial IoT, enterprise broadband



Aggregating licensed and unlicensed spectrum

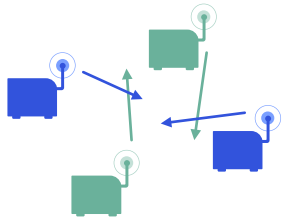
Expanding 5G market with new types of deployments

1) A private network can also support generic traffic as a neutral host, for example at an hospital it can provide dedicated services for employees/equipment and also operate as a neutral host for visitors.


Enhanced mobile broadband
Security camera
Head mounted display
Augmented Reality
Latency: <10 ms
Availability: 99.9%
Rate: Gbps-Mbps
Massive IoT
Sensors
Process Monitoring
Latency: ~100 ms
Availability: 99.99%
Rate: kbps
Automated guided vehicle (AGV)
Handheld terminal
Safety functions
Latency: <10 ms
Availability: 99.9999%
Rate: Mbps-kbps
Industrial robot
Motion control
Latency: <1 ms
Availability: 99.9999%
Rate: Mbps-kbps
Edge computing and analytics
Ultra reliable low latency

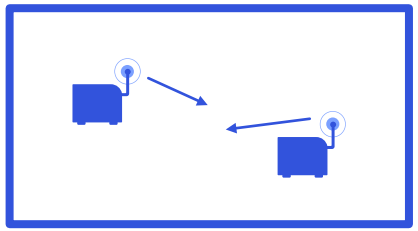
Unlicensed spectrum can support demanding Industrial IoT

Not possible with today's LBT[1] using random access



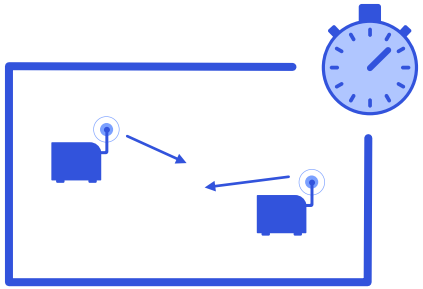
Results in random delays – demanding IIoT[2] apps require predictable latency

Controlled private environment improves latency



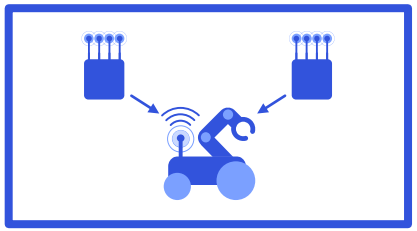
No interference from other networks, but still random delays within private network

Synchronization in time is key for predictability



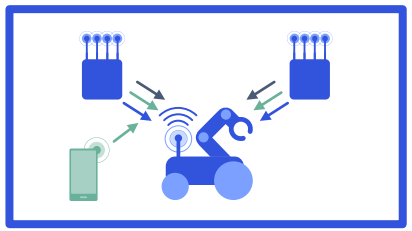
Synchronized sharing for predictable low latency

CoMP improves capacity and reliability



Time synchronization also allows for spatial 5G COMP – a key technology for URLLC

Frequency diversity improves reliability



Frequency diversity provide reliability against rogue devices trying to access spectrum

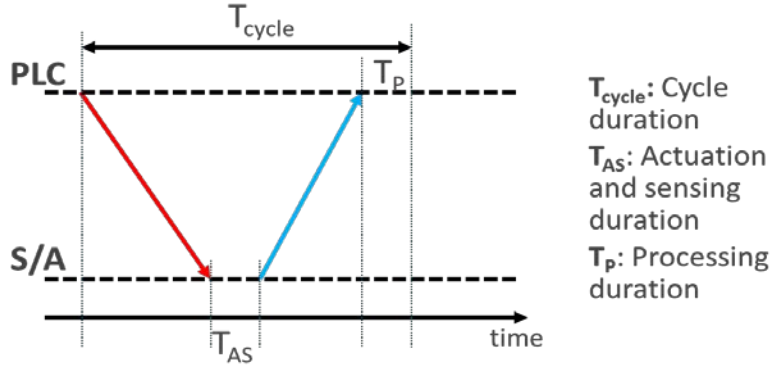
1) Listen before talk (LBT) with load based equipment rule (LBE), such as CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance); 2) Industrial IoT.

URLLC services are feasible using time synchronized NR-U

Industrial IOT

Traffic characteristics

- Factory automation communication is usually cyclic with each cycle requiring ultra reliability and low latency (URLLC)
  - Packet arrival process is periodic and predictable/deterministic
    - Periodicity = Cycle time
  - Packet arrival process is synchronized across all UEs
  - Packet arrival process is symmetric in the DL and UL directions
  - Small packets (tens of bytes)
  - Losing packet, even temporarily and occasionally, disrupts automation process

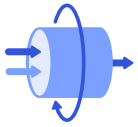


- Strong market needs for URLLC services in unlicensed/shared bands, such as 6 GHz, for industrial/hospital/venue deployments

Time Synchronization

Maximize spectral efficiency

Evolutionary path



- Asynchronous
- LBT
- But not optimized for URLLC and CoMP

5G

Time synchronization
provides great potential to share spectrum more efficiently

Revolutionary path

More predictable resources

5G CoMP

Spatial sharing

Flexible sharing

Revolutionary path

NR spectrum sharing – potential for new spectrum sharing rules
For green-field bands such as 6 GHz, 37-37.6 GHz and 64-71 GHz

Time synchronization

Improved predictability

- Prioritized resources for each operator → more predictable service
- Opportunistic sharing of unused resources

5G CoMP

- Exploiting the spatial domain with 5G CoMP
- Significantly increased capacity and reliability

Spatial sharing

- Spatial sharing between multiple operators
- Allows for simultaneous use of same spectrum in same location

Flexible sharing

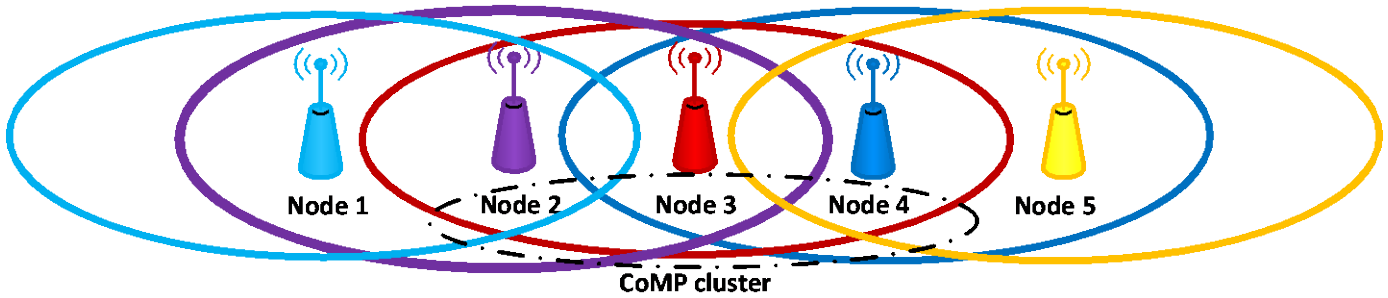
- Native support for sharing with different priority levels
- Flexible framework to support various regional sharing needs

CoMP and the need for synchronization

CoMP

Illustration of issues encountered using CoMP with asynchronous nodes

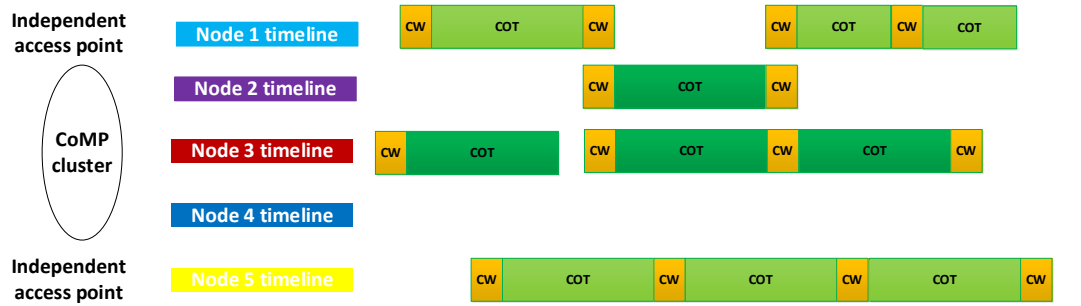
- In the CoMP scenario, adjacent nodes, commonly referred to as transmission points (TRPs), belonging to the same CoMP cluster can block each other's channel access and significantly reduce CoMP gains



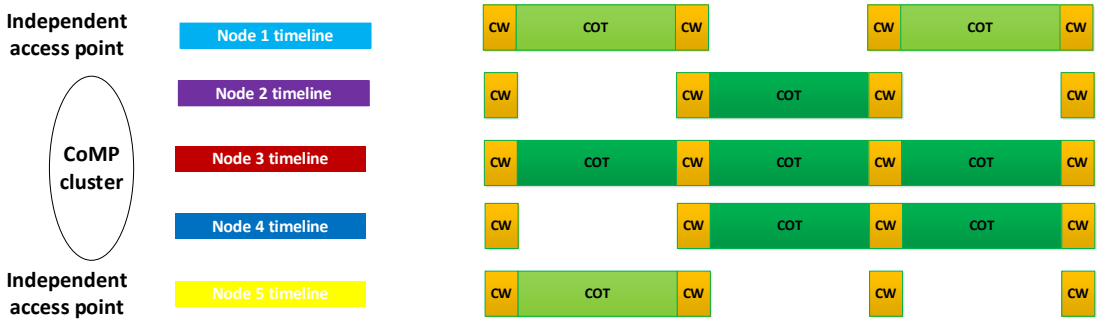
- CoMP based on independent asynchronous TRP contention relies on triggers and can only create localized clusters and is further constraint by asynchronous medium access by neighboring nodes
- How can we facilitate more efficient use of CoMP techniques in unlicensed bands, like 6 GHz?

CoMP scenario illustration

- Synchronization allows overlapping of contention windows among all nodes and enables realization of CoMP gains
  - When medium access is successful, much better performance for every node is attained



Asynchronous contention – difficult to realize CoMP mode



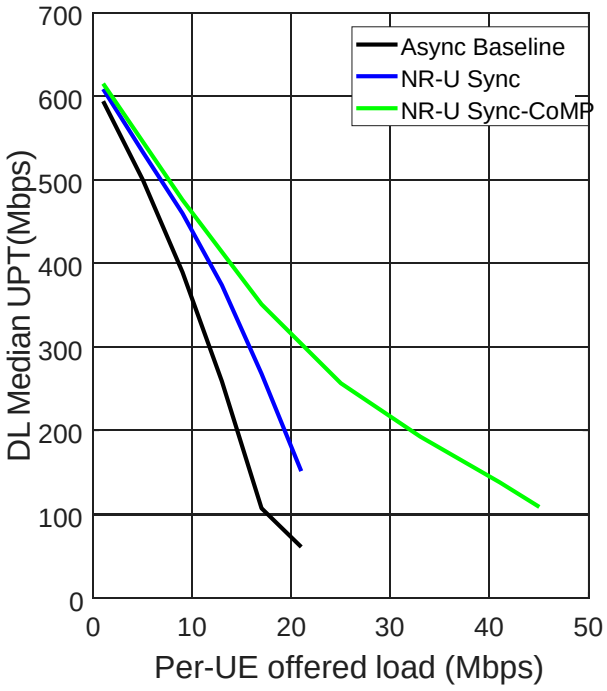
Synchronous contention – increase in probability to actually utilize CoMP mode

Benefits of CoMP with synchronous contention - simulation study

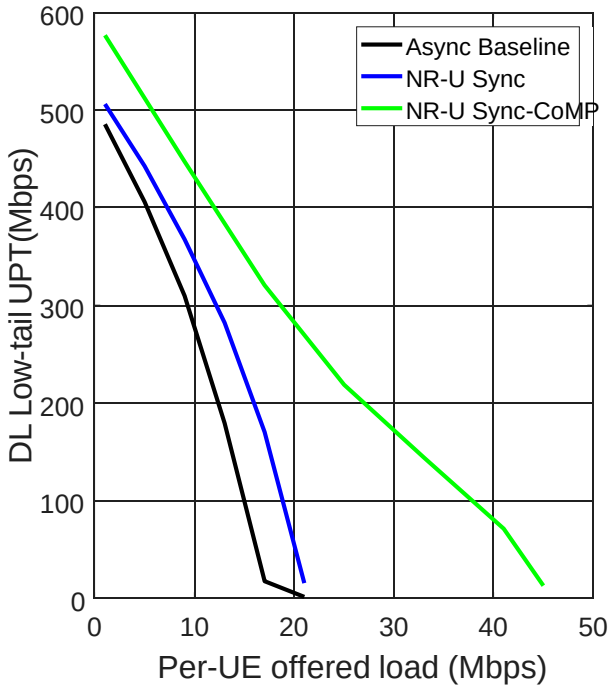
3GPP Indoor UPT vs Offered Load

3GPP Indoor, 40MHz, MIMO 4x4, 2MB burst size, 0.5:0.5 DL:UL

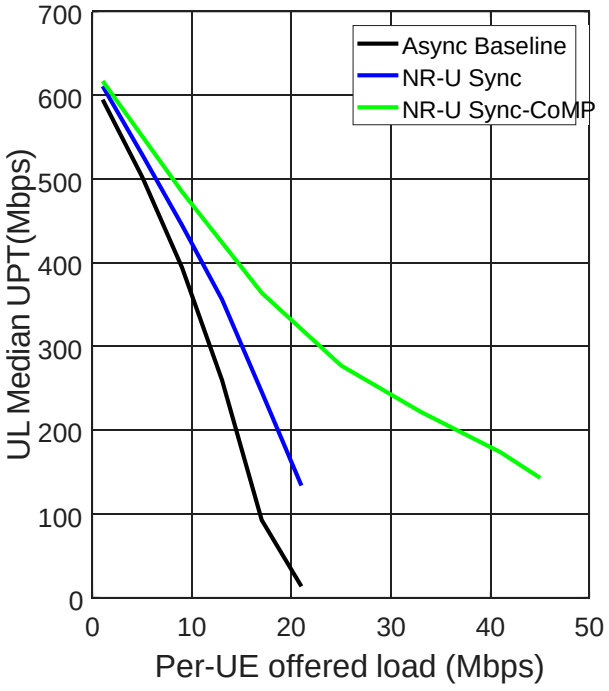
DL Median



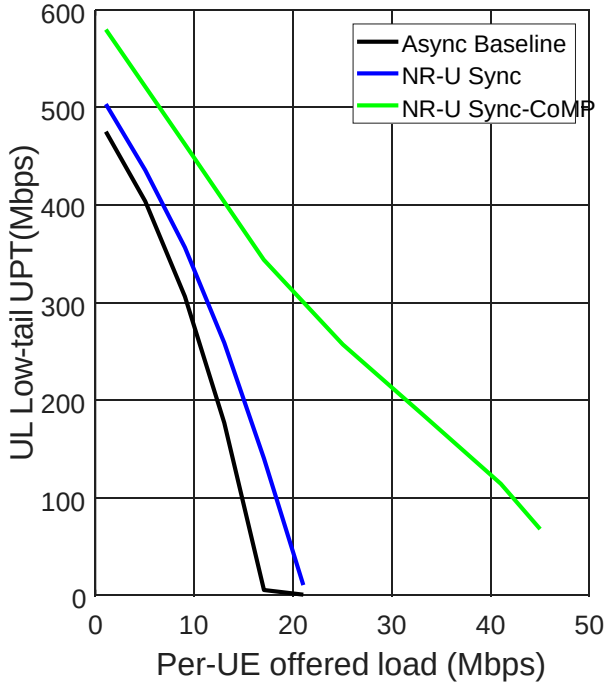
DL Low-tail



UL Median



UL Low-tail

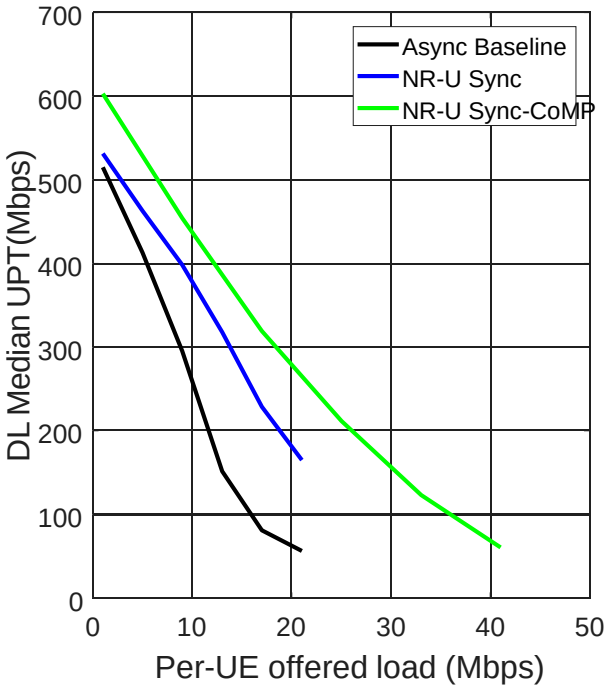


- NR-U Sync provides ≥ 25% capacity gain over async baseline (5 GHz LBT medium access procedure with NR-U)
- Advanced techniques that make use of synchronized medium access, such as CoMP, provide further 100%+ gain

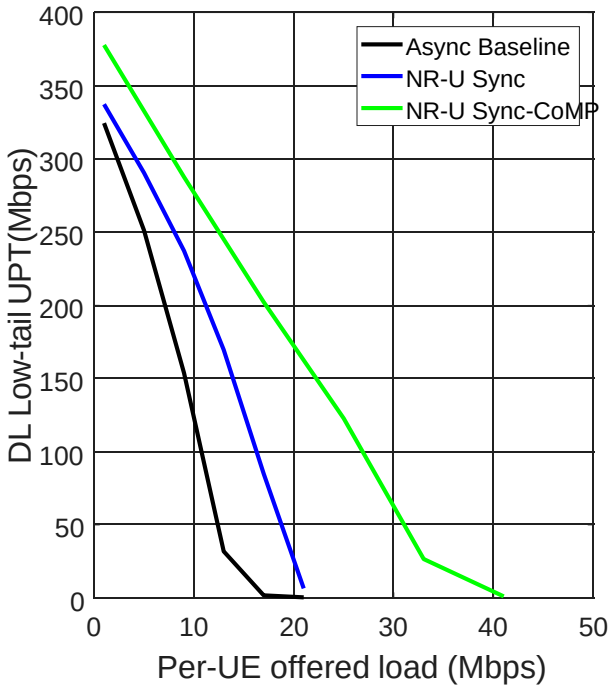
3GPP Outdoor UPT vs Offered Load

3GPP Outdoor, 40MHz, MIMO 4x4, 2MB burst size, 0.5:0.5 DL:UL

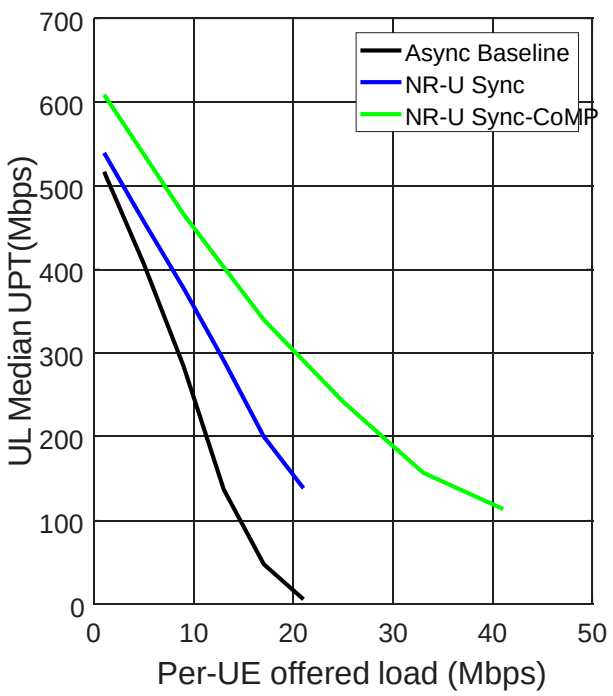
DL Median



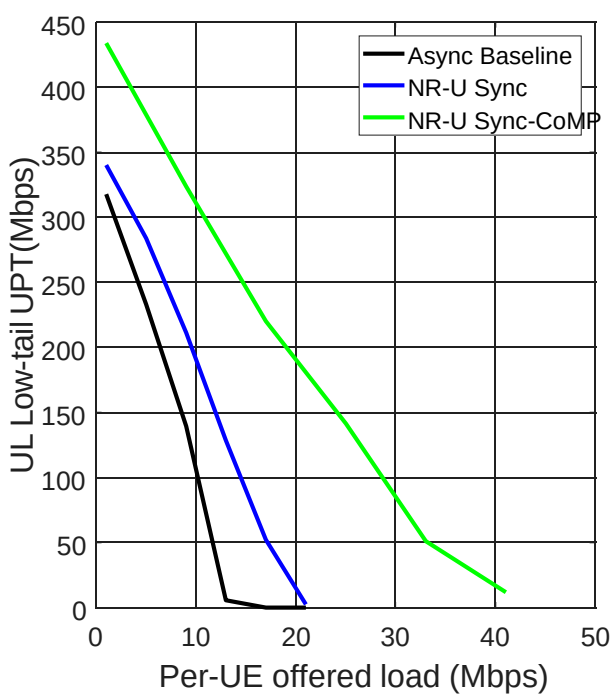
DL Low-tail



UL Median



UL Low-tail



- NR-U Sync provides ≥ 40% capacity gain over async baseline (5 GHz LBT medium access procedure with NR-U)
- Advanced techniques that make use of synchronized medium access, such as CoMP, provide further 100%+ gain

Qualcomm

Thank you

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